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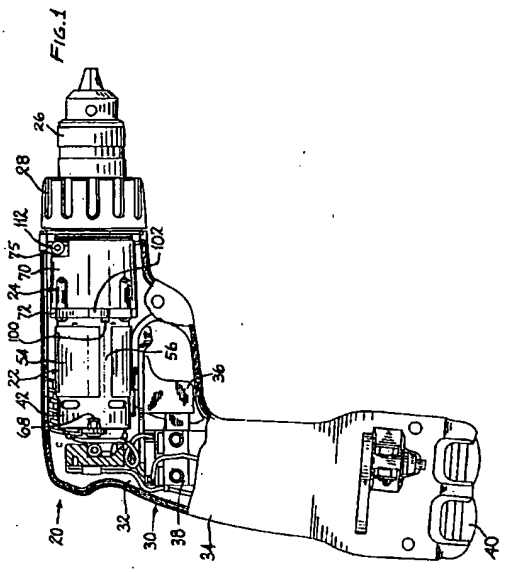
(54) Power tool with modular drive system and method of assembly of modular drive system

(57) A power tool (20) includes a modular drive system in which the motor (22) and transmission (24) consist of separate self-contained modular units which can be assembled together by simply sliding and rotating the motor housing (42) and the transmission housing (70) relative to each other. The motor (22) has a D-shaped rotary drive shaft (44) which is inserted into a D-shaped aperture (86) in the drive gear (84) of a planetary gear system (80) contained within the transmission housing (70). Guide pins (92) extending from the transmission housing (70) are inserted into guide holes (94) in the motor housing (42) when the D-shaped drive shaft (44) is inserted into the D-shaped aperture (86) in the drive gear (84) to align the housings (42,70) with each other. A bushing (46) at the front of the motor housing (42) is inserted into a central opening (76) at the rear of the transmission housing (70) to couple the housings (42,70) together.



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Description

The present invention relates to a power tool including a modular drive system and to a method of assembling a modular drive system for use in a power tool or the like. The modular drive system can be used in power tools, such as power drills and screw drivers, and in kitchen appliances, such as mixers and blenders.

In conventional power tools, e.g., hand-held power drills and screw drivers, it is known to use an electric drive motor which is coupled with a planetary gear reduction system to transmit the rotation of the motor drive shaft to a rotary chuck. Typically, the electric motor is a self-contained unit and the drive shaft of the motor is provided with a pinion gear which forms part of the planetary gear reduction system. To assemble the drive motor and the planetary gear system, a mounting plate is bolted onto the end wall of the motor housing with the motor drive shaft and the pinion gear extending through a central opening in the mounting plate. The other components of the planetary gear reduction system, i.e., the carrier plate and the planetary gears are assembled in a gear housing which supports a rotary output shaft for connection to the rotary chuck. The motor housing with the attached mounting plate is aligned with the gear housing and the pinion gear on the motor drive shaft is inserted between the planetary gears within the gear housing. The mounting plate is secured by a set of screws to the gear housing to complete the assembly of the drive system. It is also known to use bayonet-type fasteners to secure the gear housing to the mounting plate.

A primary object of the invention is to provide a power tool including a modular motor and transmission system with a simplified construction which is easily and accurately assembled.

The present invention is particularly concerned with a power tool including a modular drive system in which the motor and transmission consist of separate self-contained modular units which can be assembled together by simply sliding and rotating the motor and transmission housings relative to each other.

In accordance with one aspect of the invention, as embodied and described herein, a power tool including a modular drive assembly comprises a modular drive motor including a motor housing and a rotary drive shaft, and a modular transmission including a transmission housing which contains a planetary gear system having a drive gear including an aperture for insertion of the drive shaft. One or more guide members extend from one of the housings for insertion into one or more guide holes in the other of the housings when the drive shaft is inserted in the aperture of the drive gear to align the housings with each other.

To facilitate the assembly of the modular drive system, preferably the drive shaft is key-shaped in cross section and the aperture in the drive gear has a keyhole-shaped cross section for slidably receiving the drive shaft when the motor housing and the transmission are assembled. The guide members may comprise one or more guide pins formed on an end wall of the transmission housing and the guide holes are formed on an end wall of the motor housing for slidably receiving the guide pins. To retain the motor housing and the transmission housing together, one or more press fit ribs may be formed on each of the guide pins for frictionally engaging the inside of the guide holes.

To further stabilise the coupling of the motor and the transmission, the motor housing may include an annular bushing extending from the end wall of the motor housing and surrounding the drive shaft and the transmission housing has an opening formed in its end wall for slidably receiving the annular bushing when the motor housing and the transmission housing are assembled together. one or more press fit ribs are preferably formed on the inside of the opening for frictionally engaging the annular bushing to retain the motor housing and the transmission housing together.

Preferably, to facilitate the assembly of the modular motor and the modular transmission, the motor drive shaft is adapted to slidably engage the aperture in the drive gear before the guide pins are received in the guide holes. Also, the guide pins are adapted to slidably engage the guide holes before the annular bushing is received in the opening in the end wall of the transmission housing. This arrangement allows the modular motor and the modular transmission to be assembled by sliding the motor drive shaft partially into the aperture in the drive gear, rotating the motor and transmission housings relative to each other to align the guide pins with the guide holes, and sliding the motor drive shaft completely into the aperture in the drive gear to slide the guide pins into the guide holes.

In accordance with another aspect of the invention, a method of assembly of a modular drive system for a power tool or the like, wherein the drive system includes a modular drive motor having a motor housing and a key-shaped drive shaft and a modular transmission having a transmission housing which contains a gear system including a drive gear having a keyhole-shaped aperture, comprises the steps of:

aligning the motor and the transmission housings with each other to align the key-shaped drive shaft with the keyhole-shaped aperture and partially inserting the key-shaped drive shaft into the keyhole-shaped aperture; and relatively rotating the motor and transmission housings to align one or more guide pins on one of the housings with corresponding guide holes on the other housing and completely inserting the key-shaped drive shaft into the keyhole-shaped aperture to insert the guide pins into the guide holes.

To further stabilise the coupling of the modular drive motor and the modular transmission, the method may include the step of inserting a bushing on the motor housing into a corresponding opening in the transmission housing as the guide pins are completely inserted into

the guide holes.

The method of assembly may be facilitated by sliding the drive shaft into the aperture in the drive gear before the guide pins are received in the guide holes and sliding the guide pins into the guide holes before the bushing is received in the opening in the transmission housing.

Additional objects and advantages of the invention will be apparent from the detailed description of the preferred embodiment, the appended claims and the accompanying drawings or may be learned by practice of the invention.

The accompanying drawings which are incorporated in, and constitute a part of, this specification illustrate a preferred embodiment of the invention and together with the description serve to explain the principles of the invention. In the drawings the same reference numerals indicate the same parts.

Figure 1 is a partially cutaway side view of a power tool incorporating a modular drive system in accordance with the present invention.

Figure 2 is a side view of a motor employed in the modular drive system.

Figure 3 is a front view of the motor shown in Figure 2.

Figure 4 is a side view of a transmission employed in the modular drive system.

Figure 5 is a rear view of the transmission shown in Figure 4.

Figure 6 is an enlarged, partially cutaway side view of the assembled motor and transmission of the modular drive assembly.

Figures 7-9 illustrate the steps of assembling the motor and transmission of the modular drive assembly.

Figure 10 is a partially cutaway side view showing the interior of the power tool housing with motor and transmission removed.

Figure 11 is an enlarged perspective view of a front wall of the motor.

Figure 12 is an enlarged perspective view of a rear wall of the transmission.

The preferred embodiment of the power tool including a modular drive system is illustrated in Figures 1-5. Details of the embodiment are shown in Figures 6 and 10-12. The method of assembly of the modular drive system is shown in Figures 7-9.

Referring to Figure 1, the invention is embodied in a power tool, generally 20, e.g., a battery-powered hand-held power drill, including a modular electric drive motor 22 and a modular transmission 24 which together comprise a modular drive system for driving a rotary chuck 26. A rotatable adjustment collar 28 is mounted on the transmission 24 for adjusting the torque which is transmitted to the rotary chuck 26.

The power tool 20 has a two-part housing assembly 30 which is split longitudinally and includes a pair of mating housing sections 32 and 34 adapted to fit together to contain the motor 22 and transmission 24. The housing sections 32 and 34 are preferably made of plastic material. The power tool 20 has a manually operated trigger 36 for actuating a switch 38 to control the flow of electric current from a rechargeable battery pack 40 to the motor 22.

As shown in Figures 2 and 3, the modular electric motor 22 includes an elongated generally cylindrical motor housing 42, which is made of metal, e.g., steel. A rotary drive shaft 44 extends axially along the motor housing 42 and projects outward from the front of the motor 22. The rotary drive shaft 44 is rotatably supported on bearings (not shown) in an annular bushing or boss 46 extending forwardly from a front wall 48 of the motor housing 42 and in an annular bushing or boss 50 extending rearwardly from a rear wall 52 of the motor housing 42. The motor 22 has an annular flux ring 54 made of magnetic material, e.g. steel, and surrounding the cylindrical motor housing 42 except for a longitudinal gap 56 which extends between the opposite ends 58 of the flux ring 54. An upper terminal 60 and a lower terminal 62 extend through the rear wall 52 of the motor housing 42 for connection to the negative and positive leads, respectively, from the switch 38. The motor 22 has side vent holes 64 formed in the cylindrical motor housing 42 which also includes a set of vent holes 66 in the front wall 48 and a set of vent holes (not shown) the rear wall 52. A pair of recesses 68 (one shown) is provided on opposite sides at the rear of the motor housing 42 for engagement with the interior of the housing sections 32 and 34, as explained below.

As shown in Figure 4, the modular transmission 24 includes a generally cylindrical, hollow housing 70 and a rear wall or cover 72 which is attached by a set of screws 74 to the housing 70. Preferably, the transmission housing 70 and the rear wall or cover 72 are made of plastic material. A notch 7 5 extends transversely across a top front portion of the transmission housing 70. The cover 72 has a central circular opening 76 (Figure 5) extending axially therethrough for receiving the front bushing 46 on the motor housing 42. The cover 72 has an annular beveled guide surface 78 at the rear edge of the circular opening 76 to guide the front bushing 46 into the opening 76.

As shown in Figure 6, the modular transmission 24 includes a planetary gear system, generally 80, contained within the transmission housing 70 for driving a rotary output shaft 82. For example, the planetary gear system 80 may comprise a conventional two-stage planetary gear system.

The planetary gear system 80 has a drive gear 84 including a central aperture 86 for insertion of the drive shaft 44 of the motor 22. The drive shaft 44 is slidably received in the aperture 86 in the drive gear 84 when the motor housing 42 and the transmission housing 70 are assembled together. The drive shaft 44 is key-shaped in cross section and the aperture 86 in the drive gear 84 has a keyhole-shaped configuration to provide a coupling for transmitting the rotation of the motor drive shaft

44 to the drive gear 84 of the planetary gear system 80. In the preferred embodiment, the motor drive shaft 44 has a D-shaped configuration and the aperture 86 in the drive gear 84 has a D-shaped cross section for insertion of the D-shaped drive shaft 44. A chamfered surface 45 at the tip of the D-shaped drive shaft 44 facilitates the insertion of the D-shaped drive shaft 44 into the D-shaped aperture in the drive gear 84.

Referring to Figure 6, a circular retainer plate 88 is located inside the transmission housing 70 adjacent to the rear wall or cover 72 for retaining the drive gear 84 within the transmission housing 70. The retainer plate 88 has a central opening 90 (Figure 12) through which the motor drive shaft 44 is inserted into the aperture 86 in the drive gear 84.

In accordance with the invention, one or more guide members or pins 92 extend from one of the housings, i.e., either the motor housing 42 or the transmission housing 70, for insertion into one or more guide holes 94 in the other housing when the drive shaft 44 is inserted into the aperture 86 in the drive gear 84 to align the housings 42 and 70 with each other. In the preferred embodiment, one or more guide members or pins 92 extend rearwardly from the end wall or cover 72 of the transmission housing 70 and one or more guide holes 94 are formed in the front wall 48 of the motor housing 42. For example, a pair of guide pins 92 (Figure 12) is formed at diametrically opposed positions on the rear wall or cover 72 of the transmission housing 70. A pair of corresponding guide holes 94 (Figure 11) is formed on the front wall 48 of the motor housing 42 for slidably receiving the guide pins 92 in the assembly of the modular drive system. Alternatively, the guide pins 92 can be located on the motor housing 42 and the guide holes 94 can be located on the transmission housing 72.

In the preferred embodiment, the guide pins 92 are adapted to be press fit into the guide holes 94 to attach the transmission housing 70 to the motor housing 42. For example, one or more longitudinal press f it ribs 96 are formed on each of the guide pins 92 for frictionally engaging the inside of the guide holes 94 to retain the motor housing 42 and the transmission housing 70 together. Also, a press f it is provided between the annular bushing 46 at the front end wall of the motor housing 42 and the circular opening 76 in the rear wall or cover 72 of the transmission housing 70. For example, one or more longitudinal press fit ribs 98 (Figure 12) are formed on the inside of the opening 76 for frictionally engaging the annular bushing 46 to retain the motor housing 42 and the transmission housing 70 together.

As shown in Figure 1, an alignment tab 100 which extends rearwardly from the cover 72 of the transmission housing 70 is aligned with the gap 56 in the flux ring 54 to orient the negative terminal 60 in an upper position and to orient the positive terminal 62 in a lower position when the modular drive system is inserted into the power tool housing 30. The alignment tab 100 on the transmission cover 72 and the gap 56 in the flux ring 54 provide a visual alignment feature which facilitates the assembly of the motor 22 and the transmission 24 in the proper orientation before the modular drive system is installed in the power tool housing 30.

A pair of shoulders 102 (Figure 12) extending radially outward from opposite sides of the cover 72 is received in a corresponding pair of recesses 104 (one shown in Figure 10) formed on the interior of the power tool housing sections 32 and 34 to non-rotatably attach the transmission housing 70 to the power tool housing 30. A pair of internal, vertical flanges 106 (one shown in Figure 10) is provided on the power tool housing sections 32 and 34 for engaging the rear wall 52 of the motor housing 42 to retain the motor 22 in a desired axial position within the power tool housing 30. A pair of tabs 108 (one shown in Figure 10) located at the front of the vertical flanges 106 is engaged in the recesses 68 at the rear of the motor housing 42 to non-rotatably attach the motor housing 42 to the housing sections 32 and 34. Each of the housing sections 32 and 34 has a pair of vertical support ribs 110 which are concave in shape to receive and support the cylindrical motor housing 42.

A cylindrical connecting boss 112 (one shown in Figure 1) on each of the housing sections 32 and 34 extends transversely through the space provided by the notch 75 at the front of the transmission housing 70. Additional cylindrical connecting bosses 114 (Figure 10) are provided on each of the housing sections 32 and 34.

The connecting bosses 112 and 114 receive a set of screws (not shown) to secure the housing sections 32 and 34 together. Also,, a series of vent holes 116 is formed in each of the housing sections 32 and 34.

Another aspect of the invention is a method of assembly of a modular drive system for a power tool or similar device. The steps of the method are illustrated in Figures 6-9.

Briefly, the method comprises aligning the key-shaped drive shaft 44 of the motor 22 with the keyhole-shaped aperture 86 in the drive gear 84 of the transmission 24 and partially inserting the drive shaft 44 into the aperture 86 of the drive gear 44. The assembly is completed by relatively rotating the motor housing 42 and the transmission housing 70 to align the guide pins 92 with the guide holes 94 and completely inserting the drive shaft 44 into the aperture 86 to insert the guide pins 92 into the guide holes 94. A more detailed explanation of the assembly method appears below.

Initially, referring to Figure 7, the motor housing 42 and the transmission housing 70 are aligned with the D-shaped drive shaft 44 extending into the central opening 76 in the cover 72 adjacent to the drive gear 84. The motor housing 42 and the transmission housing 70 are rotated relative to each other to align the D-shaped drive shaft insertion into the D-shaped aperture 86 in the drive gear 84, and the D-shaped drive shaft 44 is partially inserted into the D-shaped aperture 86.

As shown in Figure 7, the D-shaped drive shaft 44 is slidably engaged in the D-shaped aperture 86 in the

drive gear 84 before the guide pins 92 are received in the guide holes 94. By sliding the motor housing 42 and the transmission housing 70 axially toward each other, the D-shaped drive shaft 44 can be partially advanced into the D-shaped aperture 86 until the guide pins 90 on the cover 72 engage the front wall 48 of the motor housing 42.

As shown in Figure 8, with the D-shaped drive shaft 44 partially inserted into the D-shaped aperture 86 in the drive gear 84, the motor housing 42 and the transmission 70 are rotated relative to each other to align the guide pins 92 on the cover 72 with the corresponding guide holes 94 in the front wall 48 of the motor housing 42. Then, by sliding the motor housing 42 and the transmission housing 70 axially toward each other, the guide pins 92 are slidably engaged in the guide holes 94 before the front bushing 46 is received in the circular opening 78 in the cover 72 of the transmission housing 70.

Next, as shown in Figure 9, after the guide pins 92 are slidably engaged in the guide holes 94, the annular bushing 46 at the front of the motor housing 42 enters the circular opening 76 in the cover 72. As the motor housing 42 and the transmission housing 70 slide toward each other, the annular bushing 46 is guided into the circular opening 76 by the beveled guide surface 78 formed on the cover 72 at the periphery of the opening 76.

Finally, as shown in Figure 6, when the front wall 48 of the motor housing 42 engages the cover 72 of the transmission housing 70, the D-shaped drive shaft 44 is completely inserted into the D-shaped aperture 86 in the drive gear 84 to completely insert the guide pins 92 into the guide holes 94. Also, the annular bushing 46 at the front of the motor housing 42 is completely inserted into the circular opening 76 in the cover 72 of the transmission housing 70 as the guide pins 92 are completely inserted into the guide holes 94.

In the assembled modular drive system, the motor 22 is axially slidably connected to the transmission 24 by the slidable engagement of the D-shaped motor output shaft 44 in the D-shaped aperture 86 in the drive gear 84 of the planetary gear system 80, by the engagement of the guide pins 92 on the cover 72 of the transmission housing 70 with the guide holes 94 on the front wall 48 of the motor housing 42, and by the engagement of the front bushing 46 on the motor housing 42 in the circular opening 78 in the transmission cover 72. The press fit ribs 96 on the guide pins 92 are frictionally engaged inside the guide holes 94 to secure the motor housing 42 and the transmission housing 70 together. In addition, the press fit ribs 98 inside the circular opening 76 frictionally engage the annular bushing 46 to further retain the motor housing 42 and the transmission housing 70 together.

It will be appreciated from the foregoing that a power tool or similar device including a modular drive system in accordance with the invention provides a low cost tool with fewer parts. The power tool 20 is easy to assemble because the motor 22 and the transmission 24 are modular units. The assembly of the motor 24 and transmission 24 is accomplished without the need for separate screws or other fasteners. No complicated assembly procedures are needed to assemble the modular drive system. Instead, the modular motor 22 and the modular 24 transmission are easily assembled by simple sliding and rotational movements relative to each other.

Claims

1 A power tool including a modular drive system, comprising:

tool housing (30) for receiving the system;

a modular drive motor (22) detachably located in the tool housing and including a motor housing (42) and a rotary drive shaft (44) and

a modular transmission (24) detachably located in the tool housing and including a transmission housing (70) which contains a planetary gear system (80) having a drive gear (84) including an aperture (86) for insertion of said drive shaft; characterised in that:

one or more guide members (92) extending from one (70) of said motor and transmission housings for insertion into one or more guide holes (94) in the other (42) of said housings when said drive shaft is inserted in said aperture in said drive gear to align said housings with each other.

2 A power tool according to Claim 1, characterised in that:

said guide members comprise one or more guide pins (92) formed on an end wall (72) of said transmission housing; and said guide holes are formed on an end wall (48) of said motor housing for slidably receiving said guide pins.

3 A power tool according to Claim 2, characterised in that:

one or more press fit ribs (96) are formed on each of said guide pins for frictionally engaging the inside of said guide holes to retain said motor housing and said transmission housing together.

4 A power tool according to Claim 2, characterised in that:

said motor housing includes an annular bushing (46) extending from said end wall of said motor housing and surrounding said drive shaft; and said transmission housing has an opening (76) formed in its end wall for slidably receiving said annular bushing when said motor housing and said transmission housing are assembled together.

5 A power tool according to Claim 4, characterised in that:

one or more press fit ribs (96) are formed on

the inside of said opening for frictionally engaging said annular bushing to retain said motor housing and said transmission housing together.

6 A power tool according to Claim 1, characterised in that:

said drive shaft is key-shaped in cross section and said aperture in said drive gear has a keyhole-shaped cross section for slidably receiving said drive shaft when said motor housing and said transmission housing are assembled together.

7 A power tool according to Claim 1, characterised in that:

said drive shaft has a D-shaped configuration and said aperture in said drive gear has a D-shaped cross section for slidably receiving said drive shaft in the assembly of said motor housing and said transmission housing.

8 A power tool according to Claim 4, characterised in that said modular transmission includes:

a retainer plate (88) inside said transmission housing adjacent to its end wall for retaining said drive gear within said transmission housing.

9 A power tool according to Claim 4, characterised in that:

said drive shaft is slidably engaged in said aperture in said drive gear before said guide pins are received in said guide holes; and said guide pins are slidably engaged in said guide holes before said bushing is received in said opening in said end wall of transmission housing.

10 A power tool according to Claim 1, characterised in that:

said tool housing includes internal ribs (104, 106, 108, 110) for engaging said motor housing and said transmission housing to retain said motor and said transmission assembled together inside said tool housing.

11 A method of assembly of a modular drive system for a power tool (20) or the like, said drive system including a modular drive motor (22) having a motor housing (42) and a key-shaped rotary drive shaft (44)
and a modular transmission (24) having a transmission housing (70) which contains a gear system (80) including a drive gear (84) having a keyhole-shaped aperture (86), characterised in that the method includes the steps of:

aligning the motor and transmission housings with each other to align the key-shaped drive shaft with the keyhole-shaped aperture and partially inserting the key-shaped drive shaft into the keyhole-shaped aperture; and

relatively rotating the motor and transmission housings to align one or more guide pins (92) on one of the housings with corresponding guide holes (94) on the other housing and completely inserting the key-shaped drive shaft in the keyhole-shaped aperture to insert the guide pins into the guide holes.

12 A method according to Claim 11, characterised in that it includes the step of:

inserting a bushing (46) on the motor housing into a corresponding opening (76) in the transmission housing as the guide pins are completely inserted into the guide holes.

13 A method according to Claim 12, characterised in that it includes the step of:

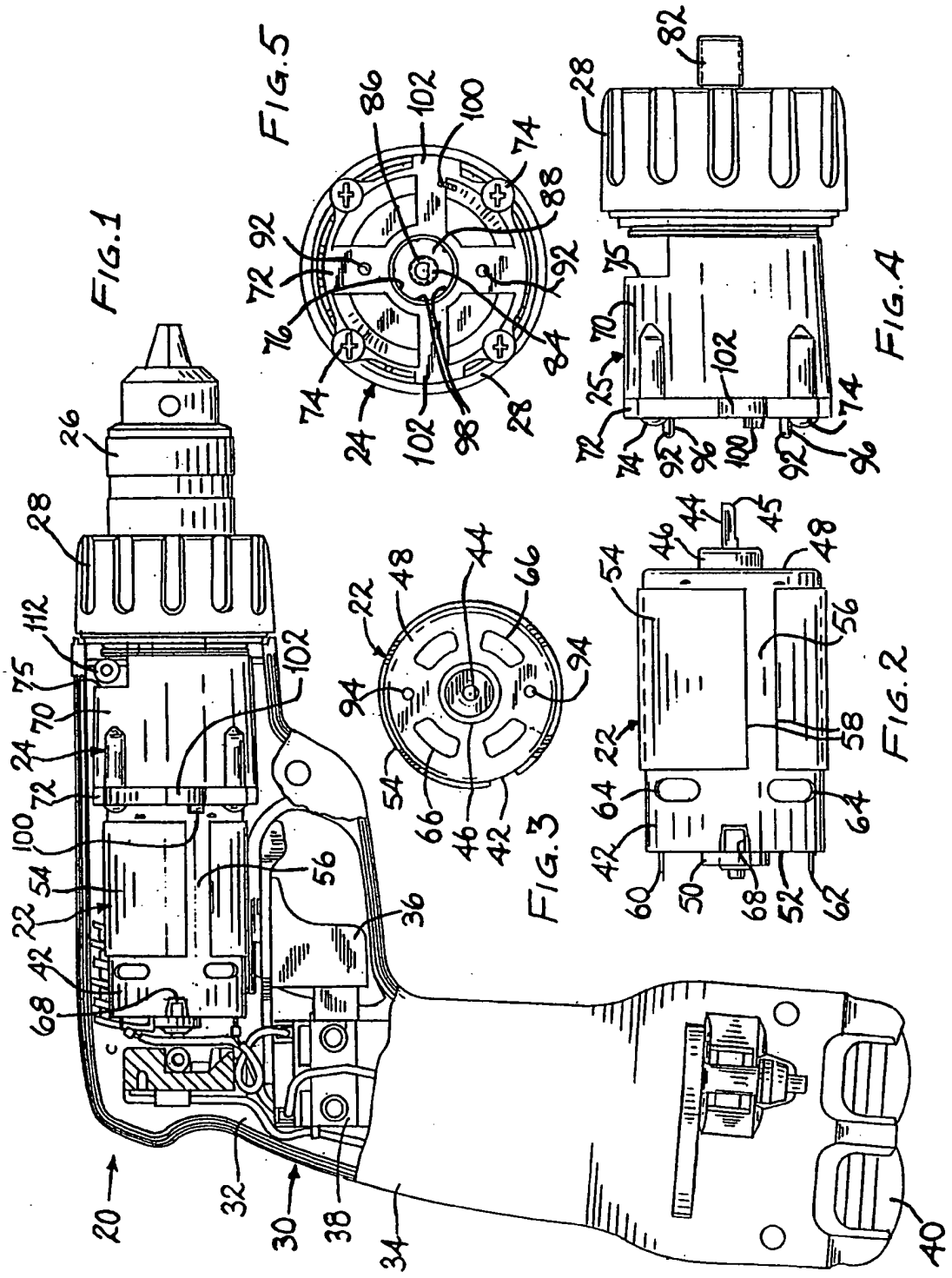
slidably engaging the drive shaft in the aperture in the drive gear before the guide pins are received in the guide holes.

14 A method according to Claim 13, characterised in that it includes the step of:

slidably engaging the guide pins in the guide holes before the bushing is received in the opening in the transmission housing.

15 A method according to Claim 14 characterised in that it includes the step of:

mounting the interconnected transmission and motor in a tool housing (30).



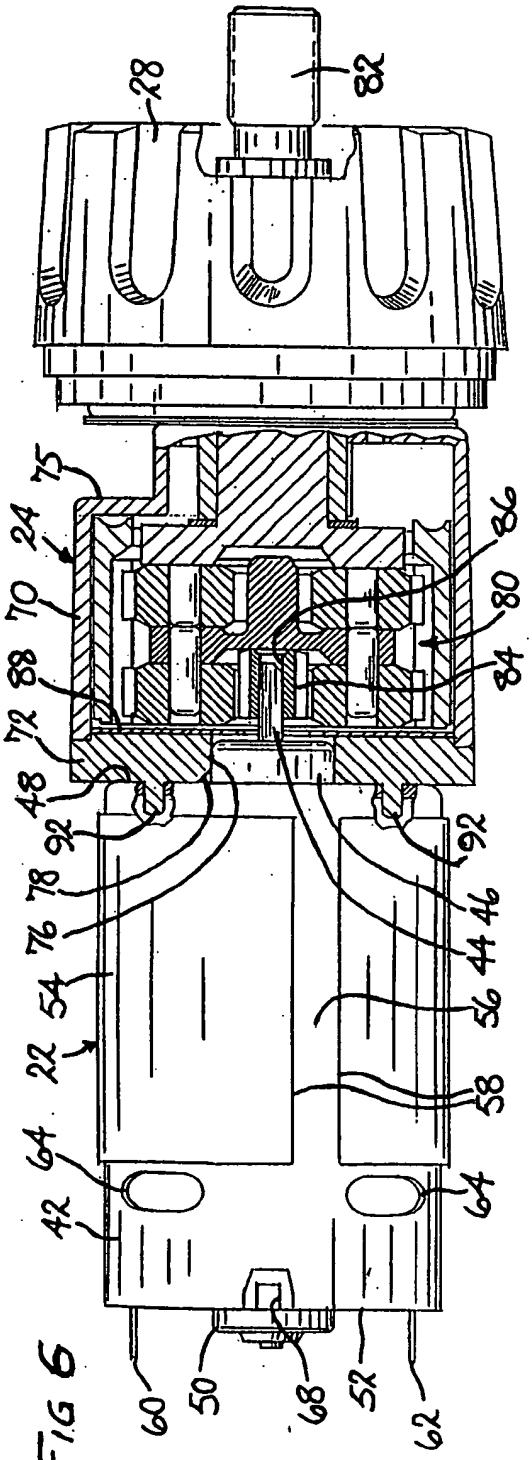


FIG 6

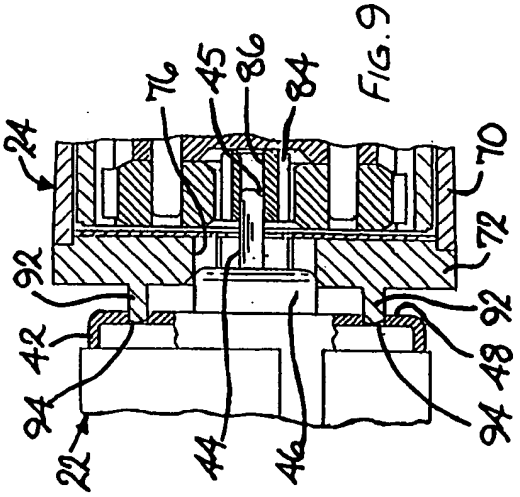


FIG. 9

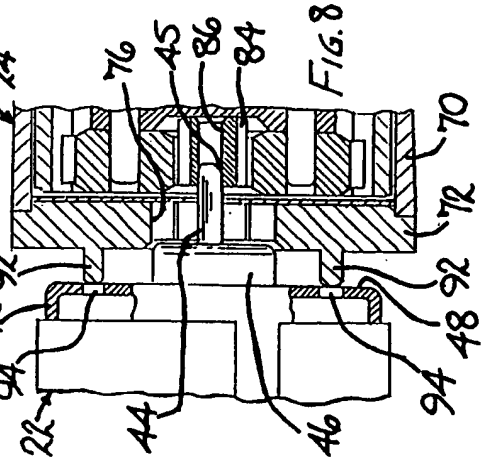


FIG. 8

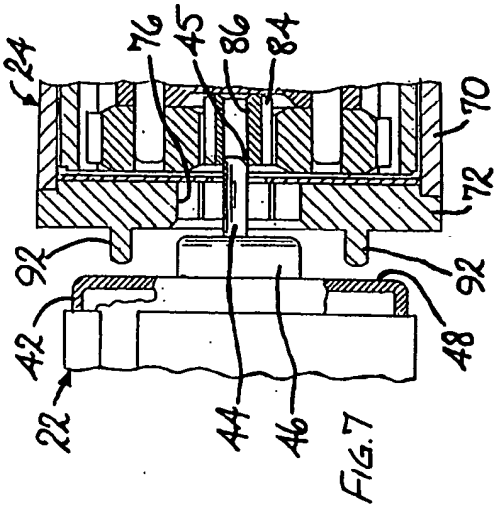


FIG. 7

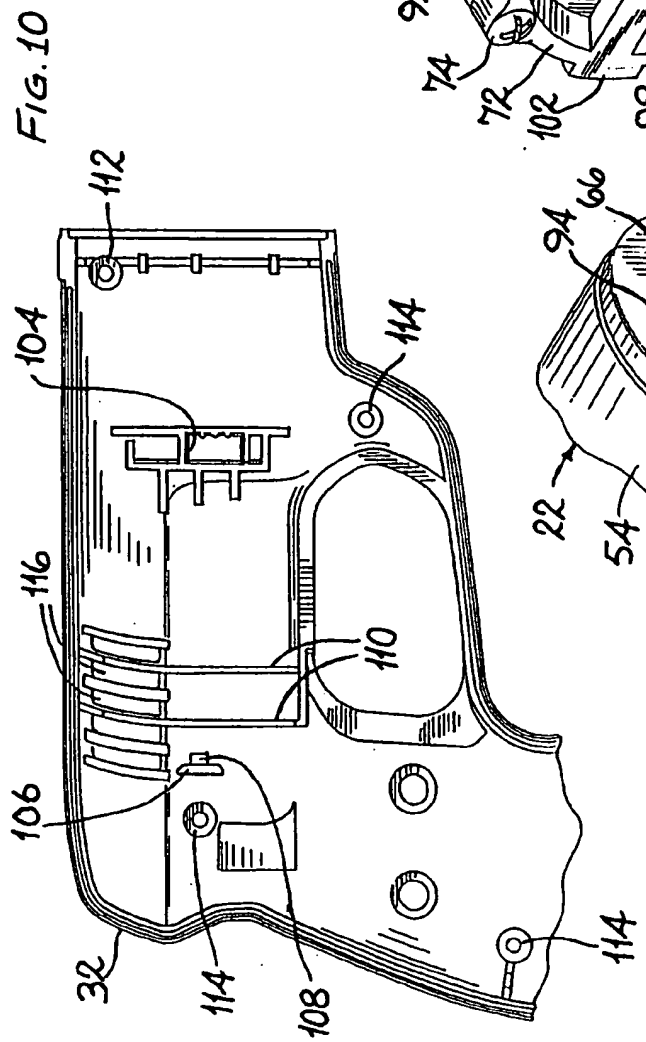


FIG.10

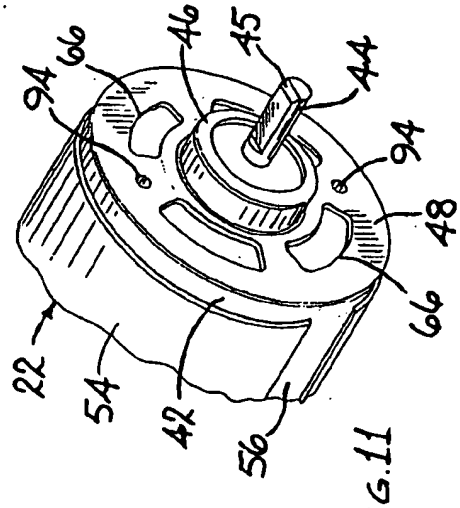


FIG.11

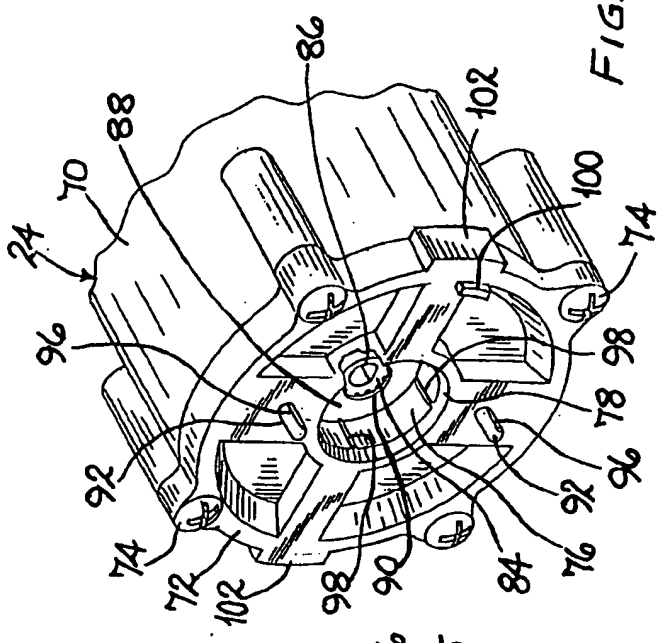


FIG.12